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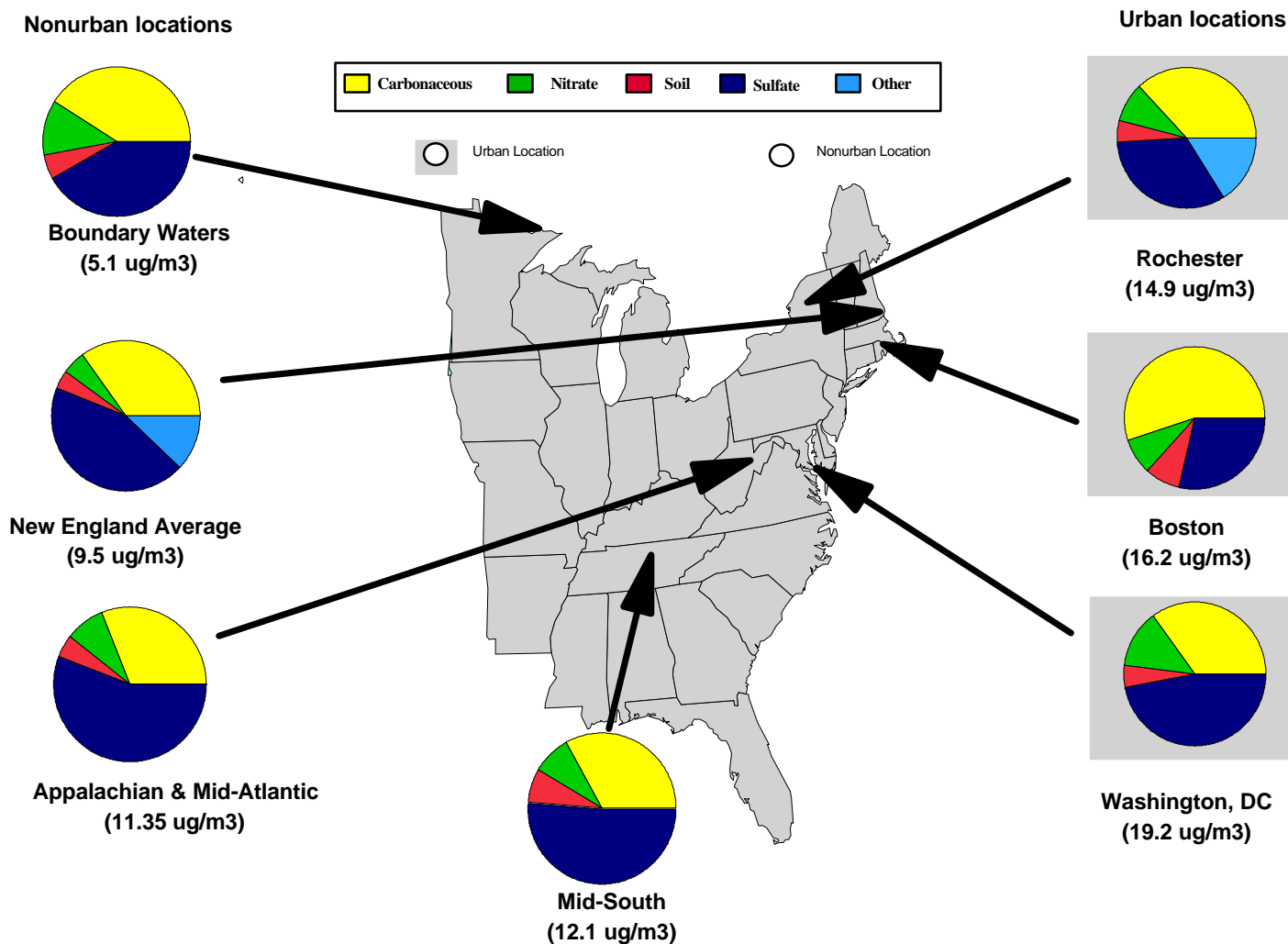
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APPENDIX A
PIE CHARTS OF SPECIATED
AMBIENT PM-2.5

NOTE: The pie charts are best viewed on the screen in color or after printing to a
             color printer. Printing these pie charts on a black and white printer may result
             in gray scale gradations that will be difficult to distinguish.
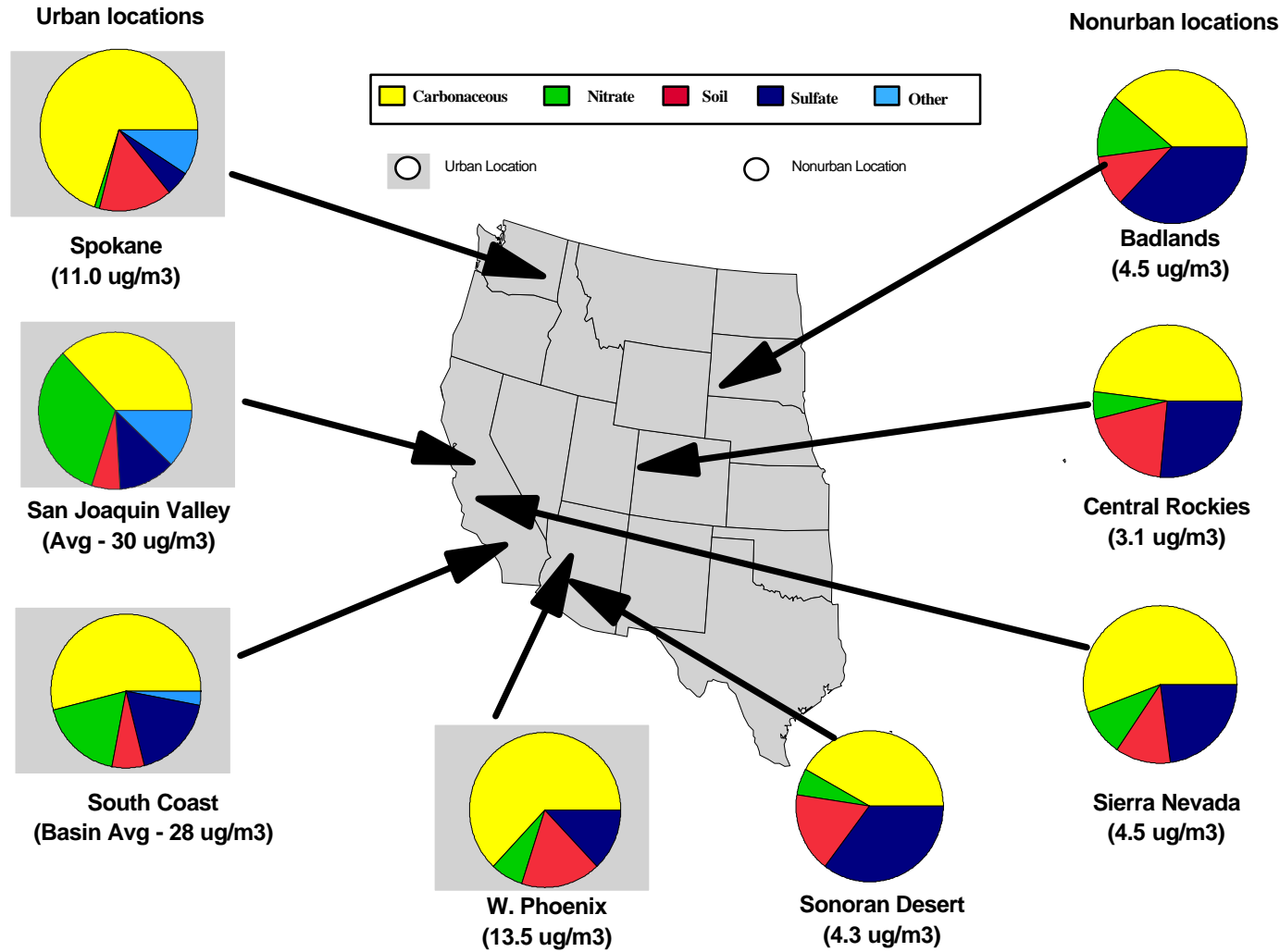
Figure A-1. PM-2.5 Composition in the Eastern United States

Nonurban locations

Urban locations

Carbonaceous   Nitrate   Soil   Sulfate   Other

Urban Location   Nonurban Location

**Boundary Waters
(5.1 ug/m3)**

**Rochester
(14.9 ug/m3)**

**New England Average
(9.5 ug/m3)**

**Boston
(16.2 ug/m3)**

**Appalachian & Mid-Atlantic
(11.35 ug/m3)**

**Washington, DC
(19.2 ug/m3)**

**Mid-South
(12.1 ug/m3)**

Note: PM-2.5 mass concentrations are determined on at least 1 year of monitoring at each location using a variety of non-Federal reference methods. They should not be used to determine compliance with the PM-2.5 NAAQS.

Figure A-2. PM-2.5 Composition in the Western United States

Urban locations

Nonurban locations

Legend: Carbonaceous, Nitrate, Soil, Sulfate, Other

○ Urban Location   ○ Nonurban Location

**Spokane
(11.0 ug/m3)**

**Badlands
(4.5 ug/m3)**

**San Joaquin Valley
(Avg - 30 ug/m3)**

**Central Rockies
(3.1 ug/m3)**

**South Coast
(Basin Avg - 28 ug/m3)**

**Sierra Nevada
(4.5 ug/m3)**

**W. Phoenix
(13.5 ug/m3)**

**Sonoran Desert
(4.3 ug/m3)**

Note: PM-2.5 mass concentrations are determined on at least 1 year of monitoring at each location using a variety of non-Federal reference methods. They should not be used to determine compliance with the PM-2.5 NAAQS.

APPENDIX B.

STATUS OF PM-2.5 EMISSIONS ESTIMATION TOOLS

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STATUS OF PM-2.5 EMISSIONS ESTIMATION TOOLS

This Appendix provides a summary of the status of available emission factors, emissions estimation algorithms, and activity data that could support the preparation of future PM-2.5 emissions inventories. The Appendix is not meant to be a comprehensive list of all factors and approaches, but rather a guide concerning the perceived strengths and weaknesses of the methods and tools that are available at this time. The specific information that is available can be obtained through readily accessible sources. Those information sources are identified in this Appendix. A summary of the available data and further needs is provided in tabular form in Table B-1.

Stationary Combustion Sources

Emission factors are available for PM-2.5 and its precursors for most stationary combustion sources. Many of the factors are based on size distribution functions. Most, if not all, of those size distribution functions were obtained through source testing using some form of size separation sampling device (e.g., cascade impactor, multi-cyclone separator). In some summaries, the factors for PM-2.5 may be presented as a percentage of PM-10 or total particulate. The reader is advised that in most cases these percentage factors are based on sampling data and are not simply an assumed fraction. These factors apply to SO_2, NO_x, VOC, and PM-2.5 for most stationary combustion sources. Many of the factors that are applied to area sources may have been developed specifically for point sources. These combustion sources should not differ widely, however, in terms of emissions per unit of fuel consumed. The PM-2.5 factors are largely representative of the filterable fraction, although in some cases, a condensable fraction or total PM-2.5 is represented. These factors can be found in *AP-42* - Fifth Edition, the supplements to the fifth edition, and in the procedures document for the 1996 NET inventory. The Factor Information Retrieval (FIRE) system lists PM-2.5 emission factors and will be continually updated as new factors are developed.

There are three remaining weaknesses related to PM-2.5 from stationary combustion sources. As indicated above the condensable component of PM-2.5 is not well characterized for many of these sources. Work is now underway to add these factors. Recent updates to *AP-42*, including Supplement D to the Fifth Edition, do include some specific factors for condensable PM-2.5 from selected source categories. The processes that result in the formation of condensable PM-2.5 are not well understood at this time. Although VOC emissions from most stationary combustion sources are typically minimal, there is the potential for some of these emissions from low temperature firing applications to participate in the formation of SOA. Currently, there is an incomplete understanding of the contribution and role of VOCs from combustion sources in the formation of SOA.

There is also a considerable lack of understanding of NH_3 emissions from point sources. The tools to adequately represent NH_3 emissions from stationary combustion sources are limited. Stationary combustion sources are not thought to be a significant source of NH_3 and, therefore, this weakness is not expected to have serious consequences in terms of National-level planning in the short term. Improvements in these factors will be needed to promote higher accuracy predictions of secondary particle formation in future studies. There are likely specific processes that will be important sources of NH_3 in some local areas. Further efforts will be necessary to address these local sources. The NH_3 factors that are available are discussed in the procedures document for the 1996 NET inventory.

Activity data for stationary combustion sources are the same as those used for these sources in the preparation of other more traditional inventories. There is adequate guidance available to assist States in the collection and organization of these data. There are no significant weaknesses related to the development of activity data for sources that are of national importance. Some weaknesses may exist in the tools and data sources for developing activity data for selected sources that are important in a limited number of local applications.

Open Burning Sources

The data sources available for estimating PM-2.5 from open burning sources arise largely from size distribution functions applied to data that had been developed to support PM-10 planning. There is a significant amount of information related to filterable PM-2.5 emissions, but less is available for the condensable fraction from all of the origins of PM-2.5 from open burning. Emissions of NO_x and VOC are also released from these sources. These sources tend to burn their fuel at lower temperatures than do boilers and other combustion related point sources. One result is an increased potential for emissions of organic carbon whether emitted directly in the solid phase or in the condensed phase. Characteristics related to NO_x and VOC emissions can also be quite different relative to high-temperature fuel combustion in boilers. The information that is available is summarized in the procedures document for the 1996 NET inventory, and additional information can be found in recently published and soon to be published EIIP documents (Open Burning Sources Chapter V, Volume 16). This guidance does not yet include information related to the agricultural or forest related sources of open burning. EPA is continuing to coordinate with organizations through the USDA and the U.S. Forest Service to develop information and resources to assist in calculating emissions from these sources. Reports will be prepared in the near future to provide information useful for application to these kinds of sources.

Activity data to support emissions estimates for these sources vary considerably. Details on available information and how to improve that information from local perspectives is provided in the EIIP documents. Additional efforts are needed to prepare adequate estimates of activity data for these sources.

Mobile Sources

Emissions of VOC and NO_x from mobile sources are routinely estimated using well established approaches and data collection techniques. Guidance from EPA's Office of Mobile Sources (OMS) and the Office of Air Quality Planning and Standards (OAQPS) is available to assist in the collection and application of both emission factors and activity data.

The data available for PM-2.5 emitted both as solid particles and as condensable material is less established. OMS has developed an emissions estimation model for PM called PART5. The current version of PART5 operates with input similar in nature to the input files used to support other mobile source emission factor models prepared by OMS. The model uses measurement data to calculate an aggregate emission factor for PM-2.5. Some issues remain concerning the application of the model. First, in its current form, the model produces a fleet average emission factor and can not separate output factors by vehicle class. This condition makes it difficult to separate out the competing influences from various types of on-road or off-road heavy-duty diesel vehicles. Overall emission factors will also include emissions from tire wear and brake wear. OMS has also recently completed an assessment of NH_3 emissions from various types of mobile source activities. These data will be reflected in subsequent national inventories (e.g., 1997 NET inventory).

All emission factors are presented in terms of VMT for on-road vehicles and in terms of hours-in-operation for off-road vehicles. Additional work is needed to improve the understanding of and data to support the development of emissions of PM-2.5 from mobile sources.

Fugitive Dust Sources

While it is generally recognized that most fugitive dust generated by construction, paved and unpaved roads, agricultural tilling, many minerals processing activities, and other crustal origins is in the coarse range (2.5 μm to 10 μm), there is still the potential for a contribution of PM-2.5 from fugitive sources in selected areas. Data on source strengths based on size distribution functions suggest that there is indeed a large amount of mass included in the emissions of particles under 2.5 μm. Speciated ambient data collected at various locations across the U.S. suggest that the amount of mass that is entrained into the prevailing transport regime, and ultimately to be collected at ambient samplers, is much lower than that emitted. One reason for this is that most (about 70%) of the emissions are within 2 meters of the ground. There are several potential physical processes that could remove or alter the fine particulate before it can reach the transport layer. Some candidate mechanisms, include impaction on nearby vegetation and structures, and rapid deposition of the particles owing to their low release height and lack of thermal bouyancy. Once investigations of these processes are completed, additional information will be made available to assist in the development of fugitive dust emissions of PM-2.5. In the meantime, estimates based on current factors and

estimation methods that have been made available at the National-level are believed to be overestimated. Obtaining activity data for many of these sources will require significant State involvement.

Agricultural Sources

Agricultural activities do contribute significantly to the burden of NH_3 in many areas. Both animal husbandry and the application of nitrogen-based fertilizers can result in NH_3 emissions. These sources are not well understood and continued research is required to develop more reliable estimates of emissions of NH_3. The results of a significant amount of research on NH_3 sources from agricultural activities completed in Europe are available. These studies represent most of the basic understanding used in estimates prepared at the National-level. These studies are well conceived and conducted, and the information is reliable and applicable. Further understanding of the specifics of animal management (conditions in feedlots, dairies, etc.) and waste management activities (lagoons, land application, confinement and treatment, etc.) is necessary to ensure that these studies are representative of actual conditions in the U.S.

Other Sources

Emissions from noncombustion industrial sources can potentially be significant in some areas. Emissions from wood products industries, and metallurgical industries can contribute to PM-2.5 loadings. It is possible that there are also other specific types of sources that might contribute to PM-2.5 emissions. States will be encouraged to explore these types of sources and develop methods and tools to estimate emissions.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING

Source Contribution to Ambient PM-2.5[1]	Emission Factors		Activity Data	
	Available Information	**Remaining Needs**	**Available Information**	**Remaining Needs**
Primary Emissions of PM-2.5				
Area Sources (1,800k tpy) (nonfugitive dust)	Emission factors for combustion and fugitive dust sources are available for most significant source categories, but improvements are needed.	Many factors do not distinguish between filterable and condensable fraction. For fugitive dust, issues remain concerning the relationship between source strength and ambient data.	Existing activity data for fugitive dust sources can be applied for PM-2.5.	In most cases, local surveys are needed for residential wood burning, wildland, and other open burning sources. Improved data are also needed for construction, unpaved roads, and silt loading on paved roads, and spatial and temporal resolution factors.
Point Sources (900k tpy)	Emission factors are available for filterable PM-2.5 for most stationary combustion sources.	Many factors do not distinguish between filterable and condensable fraction. Factors are needed for some key sources.	Standard point source fuel use and throughput data can be applied.	Some key sources that are not important in other inventory efforts may need activity data development.
Mobile Sources (600k tpy)	Emission factors can be generated using the OMS model PART5.	PART5 currently provides a fleet average factor. Revision needed to increase the level of detail available.	PART5 operates with the same VMT data that is used in other mobile inventories.	In some cases, local data on diesel/gasoline split could be useful.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING (continued)

Source Contribution to Ambient PM-2.5[1]	Emission Factors		Activity Data	
	Available Information	**Remaining Needs**	**Available Information**	**Remaining Needs**
Sulfur Precursors to Secondary Aerosol Formation				
Point Sources (16,600k tpy)	High quality emission factors are available for nearly all major combustion sources. CEM data available for many utility sources. Emission factors for smelters are reliable. Data source AP-42.	National-level analyses for industrial combustion sources based on average industry factors. Updates to reflect changes in technology could improve inventories.	Fuel use and sulfur content is routinely and reliably monitored for utilities and large industrial boilers.	Specific data for fuel use and spatial/temporal allocation of fuel use for smaller industrial boilers could improve estimates relative to national analyses.
Area (1,800 k tpy)	Point source factors applied to area source emissions for wide spread small combustion sources (e.g., small diesel generators, etc.) Data source AP-42.	Improved emission factors for open burning sources with specific studies. Relative contributions from industrial sources are small.	Fuel use and allocation are primarily dependent on growth and earlier inventory assumptions in national analyses.	Emissions at local levels based on specific activity data will be much improved over national methods.
Mobile Sources (1,300k tpy)	Emission factors for sulfur and PM from mobile sources is from PART5 and is linked to VMT estimates for fleet average. Off-road estimates based on national analyses.	Improved methods for allocation among heavy diesel on-road and off-road categories are needed. Relative contributions are small.	On-road estimates related to VMT. Off-road estimates related to national analyses of heavy diesel equipment, and other non-transportation activities.	Emissions estimates could benefit from area specific surveys of construction and other heavy diesel equipment.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING (continued)

Source Contribution to Ambient PM-2.5[1]	Emission Factors		Activity Data	
	Available Information	Remaining Needs	Available Information	Remaining Needs
Nitrogen Precursors to Secondary Aerosol Formation				
Mobile Sources (11,600k tpy)	Emission factors for on-road sources are from MOBILE models developed by OMS. Off-road sources are based on similar on-road engines.	Emission factors for off-road vehicles might be improved through specific testing.	VMT collected as part of normal ozone inventory development. National-level estimates are available. Significant guidance exists.	State data needs to be filled in for all counties that have not been subject to specific planning requirements in the past.
Point Sources (9,300k tpy)	Emission factors available for most large combustion sources; CEM data available from utilities. Data Source AP-42.	Updates to reflect changes in technology could improve inventories for industrial sources.	Fuel use and firing type is reliable for most major combustion sources.	Specific data for fuel use and spatial/temporal allocation for industrial boilers could improve emissions estimates.
Area Source (2,500k tpy)	Emission factors for industrial combustion sources are reliable. Data based on AP-42 point source factors. Factors under development for many open burning sources.	Factor for small ubiquitous units could be improved with better understanding of operating conditions. Need better understanding of wild fires and prescribed fires.	Fuel use data is routinely and reliably monitored for industrial boilers.	Fuel loading for wild and other open fires needs local development and updates.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING (continued)

Source Contribution to Ambient PM-2.5[1]	Emission Factors		Activity Data	
	Available Information	**Remaining Needs**	**Available Information**	**Remaining Needs**
Organic Precursors to Secondary Aerosol Formation				
Area Sources (8,900k tpy)	For many sources of solvent use, assumption of 100% air emissions can be made. Factors are dependent more on capture and control efficiency.	Improved factors for organic emissions including condensable from combustion and open burning (low temp. combustion) are needed.	Activity data from typical industrial sources is readily available as applied in other inventory efforts. Guidance is readily available.	Methods are needed to develop activity data for open burning and some other unique area sources. Solvent use data needs improved spatial and temporal resolution.
Mobile Sources (7,700k tpy)	Emission factors from MOBILE models by OMS and Off-Road model for non road vehicles. Factors are reliable for ozone precursor type species.	Improved factors and/or speciation profiles to represent higher carbon number compounds and semi-volatile compounds.	Activity from VMT estimates and estimates of hours in use for off road sources. National defaults are available.	Improvements can be achieved with locally derived data particularly for off-road sources. Could require surveys.
Point Sources (2,500k tpy)	Typically, point sources contribute a minimal mass of VOC emissions. Emission factors are available for most point sources in AP-42.	Speciation factors need to be reviewed to determine if low or semi volatile VOC compounds are adequate.	Activity data to support point sources emissions are well developed and guidance to develop these data is readily available.	Needs related to development of activity data for point sources generally is a low priority issue relative to PM-2.5 emissions development.

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